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now Web browsers. Today some intranets employ the groupware client as the Web browser. At the same time, intranets became so complex and cumbersome to use that it was necessary to provide some structure, some organization so that users could find what they needed on the intranet. The answer was a **portal—s**oftware that provided a structure and thus easier access to internal information via a Web browser. (If the organization desires, those external to the organization can also use the portals—see the Volkswagen example later in this section and the Haworth, Inc., box.) This added software meant that intranets became more expensive. Portal software is available from a number of software firms, both large and small, including groupware vendors IBM (with IBM WebSphere Portal), Microsoft (with Microsoft Office SharePoint Server), and Oracle (with Oracle Portal). Among other portal products are SAP NetWeaver Enterprise Portal, TIBCO PortalBuilder, Open Text Vignette Portal, and JBoss (now part of Red Hat) Enterprise Portal Platform.

Volkswagen AG has created two major portals, one internal and one external, to help the company manage the production of five million cars a year at 40 factories in 16 countries. The internal portal, known as iPAD (Integrated Purchasing Agent's Desk), provides an incredible array of information on parts to purchasing agents throughout the company. According to Meike-Uta Hansen, Director of e-Supply Chain Integration and Services, the iPAD portal "provides 360-degree views of suppliers, parts, and projects." The external, business-to-business portal enables VW to collaborate more closely with its suppliers. This portal features 30 applications, links to 16,000 supplier sites, and has 55,000 users. Through the portal, suppliers have access to the specific information they need to track VW's procurement needs; they also receive event-driven alerts to keep them up-to-date on changes in VW's plans (Travis, 2005).

Ball Memorial Hospital in Muncie, Indiana, has successfully used a portal for its physicians, and it is currently extending the portal to be useful for all its employees. Ball Memorial has used portal development tools from Bowstreet, Inc. (purchased by IBM in late 2005), along with IBM's WebSphere Portal, to build more than 20 applications for its physicians. Christina Fogle, e-Systems Manager at Ball Memorial, estimates that the tools helped shave 40 percent off the development time for complex applications and as much as 70 percent for simpler applications. The hospital is currently using the same tools for new employee self-service applications, including benefits management and travel (Whiting, 2006).

In another hospital example, Cincinnati Children's Hospital Medical Center has created a Fetal Care Portal to make available patient data, including electronic medical records and digitized radiology images, to doctors at CCHMC and two nearby hospitals where surgery on fetuses is performed, if needed. The portal permits doctors to view patient data on two side-by-side screens, with images on one screen and written reports on the other. Doctors may also access data about treatments and outcomes of other patients with the same conditions who have been treated at CCHMC and its two partner hospitals, and they can use the portal's database query tools to analyze trends and devise improved treatments (McGee, 2009b). For organizations such as Walmart, IBM, Volkswagen, Ball Memorial Hospital, Cincinnati Children's Hospital, and many others, intranets and portals have brought improved performance and communication.

FACTORY AUTOMATION

The roots of **factory automation** lie in (1) numerically controlled machines, which use a computer program, or a tape with holes punched in it, to control the movement of tools on sophisticated machines and in (2) **material requirements planning (MRP)** systems, which rely on extensive data input to produce a production schedule for the factory and a schedule of needed raw materials. The newer **computer-integrated manufacturing (CIM)** combines these basic ideas not only to let the computer set up the schedules (as with MRP) but also to carry them out through control of the various machines involved (as with numerically controlled machines).

Computer-integrated manufacturing is one of the primary ways by which manufacturers are facing the challenges of global competition. Through the various components of CIM, manufacturers are increasing productivity and quality while simultaneously reducing the lead time from the idea stage to the marketplace for most products. A list of strong proponents of CIM reads like a who's who of manufacturing—General Motors, John Deere, Ford, Weyerhauser, FMC, and Kodak, among others.

CIM systems fall into three major categories: engineering systems, manufacturing administration, and factory operations. Table 1 lists the acronyms used in this section on factory automation. The engineering systems are aimed at increasing the productivity of engineers and include such systems as computer-aided design (CAD) and group technology (GT). Manufacturing administration includes systems that develop production schedules and monitor production against these schedules; these systems are usually termed *manufacturing resources planning systems*. Factory operations include those systems that actually control the operation of machines on the factory floor. Computer-aided manufacturing (CAM) and shop floor control (SFC) are examples of such systems.

Haworth's dNet Portal

Office furniture maker Haworth, Inc., an innovator in office products with more than 250 patents to its credit, offers more than 35 million products—one of the largest selections of office furniture and products in the world. In order to better serve its 600 dealers, Haworth decided to build a portal, which it called dNet. The initial version of the portal was unsatisfactory, so Haworth chose to start again with new vendor proposals. Haworth went with a proposal from systems integrator Ascendant Technology, using IBM WebSphere Portal and IBM Lotus Web Content Management software. The new dNet portal has proved valuable for both Haworth's dealers and Haworth's own employees. Before the upgrade, the number of visitors to the portal averaged about 12 a month. After the new portal was put in place, it garnered about 4 million hits in 7 months, according to Mike Stock, dNet's manager.

The company's dealers use dNet to obtain real-time financial information, inventory status, and marketing materials. Before the upgrade, Haworth's sales representatives would spend more than 30 minutes per customer call to search various databases for product availability, pricing, and order-status information. Dealers can now do much of this work for themselves. The portal has also increased productivity for other Haworth employees. "Internally, all of our employees now have a centralized place to access order-entry, marketing materials, and product-development information," Stock says. "They no longer have to walk down the hall or call across the room to get information like part numbers." dNet has been a big success for Haworth: The company has been able to reduce the amount of time employees spend on customer service, increase security of financial information, and increase overall efficiency in its processes.

[Based on Ascendant Technology, 2010; and Hulme, 2005]

TABLE 1 Abbreviations Used in Factory Automation

Acronym	Full Name
CIM	computer-integrated manufacturing
CAD	computer-aided design
CAE	computer-aided engineering
GT	group technology
CAPP	computer-aided process planning
MRP	material requirements planning
MRP II	manufacturing resources planning
SCM	supply chain management
CAM	computer-aided manufacturing
AGV	automated guided vehicle
MAP	Manufacturing Automation Protocol
SFC	shop floor control

Engineering Systems

Computer-aided design (**CAD**) is perhaps the most familiar of the engineering systems. CAD involves the use of computer graphics—both two-dimensional and three-dimensional—to create and modify engineering designs. **Computer-aided engineering** (**CAE**) is a system designed to analyze the functional characteristics of a design and simulate the product performance under various conditions in order to reduce the need to build prototypes. CAD and CAE permit engineers to conduct a more thorough engineering analysis and to investigate a wider range of design alternatives. Advanced CAD/CAE systems store the information they generate in a database that is shared with the other components of CIM, such as CAM.

Group technology (**GT**) systems logically group parts according to physical characteristics, machine routings through the factory, and similar machine operations. On the basis of these logical groupings, GT is able to identify existing parts that engineers can use or modify rather than design new parts, simplifying the design and manufacturing processes. **Computer-aided process planning** (**CAPP**) systems plan the sequence of processes that produce or assemble a part. During the design process, the engineer retrieves the closest standard plan from a database (using the GT classification of the new part) and modifies that plan rather than starting from scratch. The resulting plans are more accurate and more consistent, thereby reducing process planning and manufacturing costs.

Manufacturing Administration

Manufacturing resources planning (**MRP II**) systems usually have three major components: the master production schedule, material requirements planning, and shop floor control. The master production schedule component sets the overall production goals based on forecasts of demand. The MRP component then develops a detailed production schedule to accomplish the master schedule, using parts explosion, production capacity, inventory, and lead-time data. The shop floor control component releases orders to the shop floor based on the detailed production schedule and the actual production accomplished thus far. MRP II systems attempt to implement just-in-time (JIT) production. Note that MRP II does not directly control machines on the shop floor; it is an information system that tries to minimize inventory and employ the machines effectively and efficiently.

In our discussion of enterprise resource planning (ERP) systems earlier in this chapter, we noted that MRP is often one of the key modules of an ERP system. Thus, such an ERP system ties together the manufacturing production schedule with the other important aspects of running an enterprise, including sales and distribution, human resources, and financial reporting. The latest type of manufacturing administration system—supply chain management (SCM)—goes beyond ERP and outside the boundaries of the firm itself. In our view, SCM systems are so important that we have chosen to treat them as a separate application area in a section that immediately follows the factory automation section.

Factory Operations

Factory operations systems go a significant step further than MRP II—they control the machines. By definition, **computer-aided manufacturing** (**CAM**) is the use of computers to control manufacturing processes. CAM is built around a series of computer programs that control automated equipment on the shop floor. In addition to computer-controlled machines such as automated drill presses and milling machines, CAM systems employ automated guided vehicles (AGVs) to move raw materials, in-process materials, and finished products from one workstation to another. AGVs are loaded using robot-like arms and then follow a computer-generated electronic signal (often a track under the floor that has been activated) to their next destination. Workers are used only to provide maintenance on the equipment and to handle problems. Because job setups (preparing a machine to work on a new part) are automated and accomplished in minimum time, CAM permits extremely high machine utilization. With the low setup time, very small batches (even as small as one) can be produced efficiently, shortening production lead times and reducing inventory levels.

As this brief description has implied, a CAM system is very sophisticated and requires a great deal of input data from other systems. Product design data would come from CAD, process design data from CAPP, and the master production schedule and material requirements from MRP II. The CAM system must also be able to communicate electronically with the machines on the shop floor.

The manufacturing communications network is likely to employ the **Manufacturing Automation Protocol** (**MAP**), pioneered by General Motors and now accepted by nearly all major manufacturers and vendors. MAP is a communications protocol (a set of rules) to ensure an open manufacturing system. With conformance to MAP by all vendors, seamless communication between all equipment on the factory floor—regardless of the vendor—is possible. MAP is a user-driven effort, and the details of the concept are evolving. Nevertheless, MAP is a reality in factory automation upon which future systems will be based.

Within factory operations applications, **shop floor control** (**SFC**) systems are less ambitious than CAM but are still important. These systems provide online, real-time control and monitoring of machines on the shop floor. For example, the SFC might recognize that a tool on a particular milling machine is getting dull (by measuring the metal that the machine is cutting per second) and signal this fact to the human operator on duty. The operator can then take corrective measures, such as instructing the SFC to change the tool or changing it himself or herself, depending on the system.

Robotics

Outside the broad area of CIM, robotics is one other aspect of factory automation that deserves mention. Robotics is, in fact, one branch of the artificial intelligence tree. (Artificial intelligence, especially expert systems and neural networks, is discussed in the chapter.) With robotics, scientists and engineers are building machines to accomplish coordinated physical tasks in the manner of humans. For over two decades, robots have been important in manufacturing to accomplish simple but important tasks, such as painting and welding. Robots perform repetitive tasks tirelessly, produce more consistent high-quality output than humans, and are not subject to such dangers as paint inhalation or retinal damage. Newer robots incorporate a certain amount of visual perception and thus are able to perform assembly tasks of increasing complexity. Industrial robots are expensive, but they are becoming economically viable for a wider range of tasks as their capabilities are extended. Robots and CIM are producing a vastly different "factory of the future" based on IT.

SUPPLY CHAIN MANAGEMENT SYSTEMS

Supply chain management (**SCM**) systems are designed to deal with the procurement of the components a company needs to make a product or service and the movement and distribution of components and finished products throughout the supply chain. These supply chain management systems are often interorganizational in nature, involving two or more levels of the supply chain—such as a manufacturer and its suppliers or a retailer and its suppliers. There are five basic components of SCM: plan, source, make, deliver, and return. Planning means developing a strategy, with appropriate metrics, for managing all the resources that are needed to meet customer demand for your product or service. Sourcing is choosing the suppliers for the resources needed to produce your product or service, as well as developing pricing, delivery, payment, and inventory management processes for these resources. Making is the manufacturing step, including scheduling the activities required. Delivering is the logistics associated with getting your product or service to customers, and returning is creating a procedure for handling defective and excess products and supporting customers who have problems (Worthen, 2007).

Each of these five basic components actually consists of dozens of specific tasks, and SCM software has grown up around these specific tasks, such as demand planning, inventory management, and transportation planning. SCM software packages are available to handle a few of these specific tasks, or many of them, but no vendor has a complete package that is right for every company. Each company must carefully assess its needs, and select the package—or perhaps the combination of products from several vendors—that best meets its needs. Among large companies, the SCM market tends to be dominated by the ERP vendors, especially SAP and Oracle; Microsoft has a significant presence in the small and medium business SCM market. Other important SCM vendors are JDA Software Group, Ariba, Inc., Manhattan Associates, and RedPrairie. JDA Software Group, which traditionally had strength in SCM for retailers, merged with Manugistics in 2006 and i2 Technologies in 2010, both of which had strength in SCM for manufacturers. With these mergers, JDA Software Group moved into the number three position in the SCM field, behind industry giants SAP and Oracle.

An interesting use of SCM occurs at Perdue Farms, which produces more than 48 million pounds of chicken products and almost 4 million pounds of turkey products each week. For Thanksgiving, Perdue will ship roughly 1 million whole turkeys—and all these turkeys will arrive at the supermarkets within 24 hours of processing. This logistics task is much easier for Perdue after the company invested $20 million in Manugistics SCM software, including forecasting and supply chain planning tools. With the aid of the SCM system, Perdue has gotten much better at delivering the right number of turkeys to the right customers at the right time, according to Chief Information Officer Don Taylor. “As we get to November, we have live information at our fingertips,” he says.

Perdue also uses technology to make sure its products arrive fresh. Each of its delivery trucks is equipped with a global positioning system, so dispatchers always know where the trucks are and can send out replacement trucks if necessary. Some supermarkets have vendor-management inventory control systems, which allow Perdue to track sales of its products in real time (Luttrell, 2003).

Imperial Sugar, the third-largest sugar refinery in the United States, experienced a terrible disaster in February 2008 when its refinery in Port Wentworth, Georgia, exploded, resulting in deaths and injuries to employees. The explosion destroyed approximately 60 percent of Imperial Sugar’s production capacity, and it turned out to be twenty months before the sugar refinery was online again. Imperial Sugar’s Chief Information Officer, George Muller, credits its SCM system, especially its demand-management software, with helping the company make the best of available resources and satisfying as many of its customers as possible. According to Muller, the demand-management software from Demand Foresight “took our demand, our inventory and capacity, and the number of new orders coming in and tied it all together. We couldn’t fulfill every order, but we were able to fill more orders than we ever would have had we not had that tool.” SCM software helped keep Imperial Sugar going in the face of disaster (Overby, 2010).

As an example of SCM in the retail industry, let’s consider J. C. Penney, an $18.4 billion company. In 2002, J. C. Penney implemented an inventory management system from i2 Technologies and a forecasting and replenishment system from Teradata. Based on the success of these systems and other changes in the supply chain and product development processes, J. C. Penney has reduced the time it takes to get a product from the design stage to the sales floor from as long as two years to just 45 days, according to Jeffrey Allison, J. C. Penney Executive Vice President and Director of Planning and Allocation.

In 2003, J. C. Penney created its factory-store system, which enables the store to replenish such basics as towels, sheets, and jeans on an as-needed, just-in-time basis. Because J. C. Penney can now get these items directly from its suppliers, who can produce them in a matter of days, the company no longer has to store them in warehouses, said Peter McGrath, J. C. Penney’s Executive Vice President of Product Development and

Sourcing. "The direct-to-store program allows J. C. Penney to ship weekly from global suppliers within five to seven days of receipt of an order. This saves J. C. Penney approximately $30 million in average monthly inventory investment. Beyond reducing our warehouse inventory and improving our in-stock percents, we believe that cycle time and turnover should improve as well," indicated McGrath. Virtually all the suppliers that manufacture J. C. Penney's private label merchandise are linked to this system (Levinson, 2005). SCM is working for Perdue Farms, Imperial Sugar, J. C. Penney, and many other companies.

Summary

Today virtually all large and midsized businesses and an increasing number of small businesses depend on enterprise IT systems. These systems support almost every function of the business, from procuring raw materials to planning the production schedule to distributing the product, from recording and summarizing sales figures to keeping track of inventory, from paying employees and suppliers to handling receivables, from maintaining the organization's financial records to enabling employees to communicate more effectively. Modern organizations simply require enterprise IT systems to do business.

Transaction processing systems are central to the operations of almost every business. These workhorse systems, which were the very first IT applications installed in most businesses, process the thousands of transactions that occur every day, including sales, payments, inventory, and payroll. In recent years, many large and midsized businesses have turned to enterprise resource planning (ERP) systems as a way to achieve an integrated set of transaction processing applications. ERP systems typically consist of a number of modules to handle the sales and distribution, manufacturing, financial reporting, and human resources areas, and the organization can buy a subset of these modules to satisfy its needs.

Transaction processing systems handle the volume of transactions generated as a firm does business, and they also produce summary reports on these transactions. They do not, however, provide this transactional data in a form that enables managers to use the data in decision-making activities—data warehousing does this. With data warehousing, organizational data are made accessible from a storage area that is distinct from that used for operational transaction processing. When combined with easy-to-use analysis tools, the data warehouse becomes a critical information resource for managers to enable strategic and operational decision making.

Office automation systems affect every knowledge worker in a firm. Word processing, electronic calendaring, electronic mail, and many other applications are most commonly delivered via an employee's PC attached to the organization's network. Groupware is a popular way of providing office automation functionality in an integrated package. Microsoft Exchange and Lotus Notes, the most popular groupware packages today, provide e-mail, calendaring, document sharing, and other features. Intranets—networks within an organization that employ Internet standards—offer employees easy access to an organization's internal information via a Web browser, with portals providing a valuable structure for accessing these intranets. Factory automation applies IT to the task of increasing efficiency and effectiveness in the manufacturing process. A particularly important factory automation application is supply chain management, which enables more efficient management of the supply chain as a process from supplier to manufacturer to wholesaler to retailer to consumer (or at least some portion of that supply chain).

Review Questions

1. Consider the enterprise systems application areas listed in Figure 1. Which application area developed first? Which one is most common today? What is a "hot" application area today?
2. Describe the fundamental differences between batch processing and online processing. What is in-line processing?
3. What is a vertically integrated information system? Give an example.
4. What is a client/server system? What is a client? What is a server? Why would an organization choose to implement a client/server system?

5. Explain the concept of virtualization. Describe at least one type of virtualization that is being used in IT shops today. Why is virtualization becoming important?
6. Define *middleware*. What are the three categories of middleware?
7. What is service-oriented architecture, and how does it relate to Web services?
8. List the primary categories of modules that are likely to be offered by a major ERP vendor.
9. What are the primary reasons for implementing an ERP system?
10. What is groupware? What are the features likely to be included in a groupware product?
11. What is an intranet? Why would an intranet be implemented?
12. Some of the most important acronyms used in the factory automation area are listed below. Provide the full names for each of these acronyms, and give a one-sentence explanation of each term.

CIM	SCM
CAD	GT
MRP	MRP II

Discussion Questions

1. Differentiate between a two-tier client/server system and a three-tier client/server system. Differentiate between a fat client and a thin client. Why would a firm choose one of these approaches over the others when implementing a client/server system?
2. In review question 6, you listed the three categories of middleware. In one sentence each, define the three categories. Explain the role of each category and how they interact.
3. In this chapter, payroll and order entry were used as examples of transaction processing systems. Another example with which all of us are somewhat familiar is the check-processing system employed by your bank. Consider how the check-processing system is similar to (and different from) the two examples in this chapter. Is the check-processing system likely to be batch, online, or some hybrid of the two? What subsystems would be required to operate the check-processing system?
4. Why do many firms find it difficult to implement an ERP system? List all the reasons you can think of, and indicate which reasons you think are most important and why.
5. Every large organization has large files or databases containing data used in operating the business. How does a data warehouse differ from these operational files or databases? Why are these differences important?
6. Consider an office environment with which you are somewhat familiar. Over the past decade, what changes in the way the office operates (including communication, document preparation, and scheduling meetings) have been brought about by office automation? Why do you think these changes have occurred? Have they been technology-driven or people-driven, or both?
7. Based on your reading and knowledge from other sources, in what ways has the phenomenon of the Internet influenced office automation?
8. Explain the concept of Software as a Service (SaaS), and describe at least one application area in which SaaS is becoming important. Do you think the use of SaaS will expand, and why or why not?
9. Find out if the university where you are enrolled, or the company where you work, or the company where a close relative or friend works, has developed a portal for employees (or students) to access information and applications on the organization's intranet. If possible, log into the portal and find out what services are available.
10. The terminology employed in factory automation is often confusing, in part because the names are so similar and in part because the subareas do indeed overlap. Carefully distinguish among CIM, CAD, CAE, CAM, and CAPP, indicating any overlaps.
11. All of us come into contact with distributed systems almost every day, even if it is only while shopping at Walmart or Sears. Describe a distributed system with which you have come in contact. In your view, what are the advantages and disadvantages of this system? Is the system you described a client/server system?
12. What factors are pushing organizations to adopt service-oriented architectures, and what factors are holding them back? Considering these factors, do you believe that SOA will be adopted, but slowly; that SOA will be adopted rapidly; or that SOA will disappear as another good idea that simply costs too much?

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